Plasma wakefield diagnostics with oblique crossing angle probe

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In this work, we present an experimental result from TA2 on capturing wakefields. The diagnostic was performed by sending a laser pulse as a probe crossing the wakefield at an oblique angle. This makes it possible to capture the wakefield at a certain position in plasma. Picture of modulations with similar wavelength with plasma wakefields are shown in the report. This experiment serves as a proof-of-concept of plasma wakefield diagnostics in a long plasma column and evolving wakefield, as in AWAKE experiment.

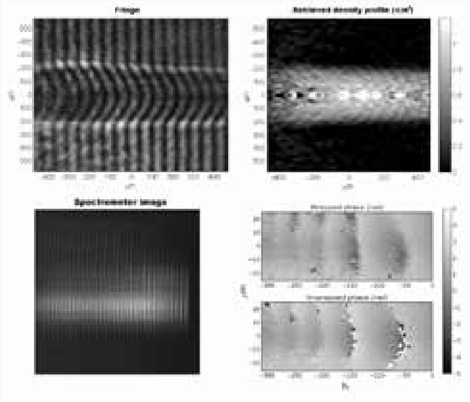

Figure 1. (Top, left) Mach-Zehnder interferometer result on the plasma density profile diagnostic. The modulation at the axis position in Figure (top, right) is due to the singularity near the axis in Abel inversion.
(Bottom, left) The spectrometer image of the spectral interferometry by the oblique angle probe pulses. (Bottom, right) The retrieved wrapped and unwrapped phase modulation when the plasma was present.

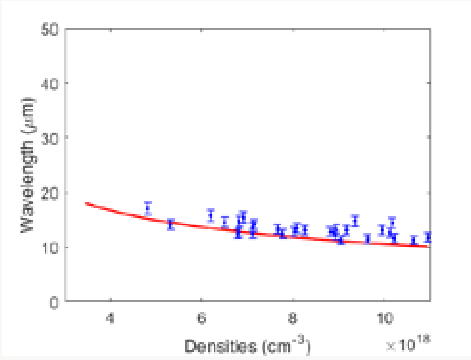

Figure 2. Plot of wakefield wavelengths against the plasma densities. The red line shows the theoretical wavelength.

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Measurement of the LWFA Betatron source length by cross-correlations over images of granular random targets

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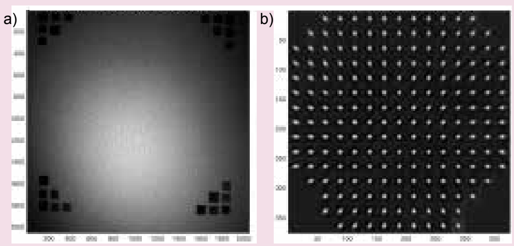
Electron beams being accelerated in laser driven plasma waves have micron size radial oscillations resulting in a forward flash of betatron radiation. In large laser systems like Gemini, it becomes very bright (>10^{12} photons per pulse), energetic (hard x-rays) and can be used for time resolved high-quality x-ray microscopy in absorption or phase-contrast.

A new method to characterize these x-rays beams was tested using Gemini. The blurring of an image of a random granular target (we used sand paper) is analysed and used to measure x-ray emission length and beam direction. The random but regular pattern of the target allows the image blurring to be mapped by autocorrelation of small samples of the image, and the emission length to be inferred. This diagnostic can be used to measure the blurring due to source length of a beamline in a single shot and to optimize the beamline for imaging with a reduced number of shots.



a) imaging of random granular target used to measure the blurring introduced by the x-ray emission length. b) montage of the image sample autocorrelations. We can see the autocorrelation in the centre of the beam presents a round shape corresponding to approximately the point spread function of the detector, but it becomes elongated with increasing radius due to the effect of the emission source length. This image is the extreme case for easy visualization of the effect. Using this diagnostic it is possible to optimize the beamline so this effect becomes negligible.

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